Annex 2: Proposed Evaluation Methodology

1. Introduction and Summary

Rain effects increase system unavailability as compared with clear-sky operations, by adding receiver system noise temperature. The presence of NGSO system interference further increases system noise temperature and therefore system unavailability. These and many other factors must be considered in evaluating numerical system availability in the presence of NGSO.

This Annex provides details of the Monte Carlo methodology proposed to evaluate the increase in BSS unavailability caused by NGSO interference. First, a complete but also complex equation for unavailability is derived. The equation is then simplified with approximations. A procedure for evaluating one of the simplified equations with Monte Carlo simulation is presented. An example result of using the simulation is discussed. Finally, derivation of the slope of the Transition Regime (B) for the proposed epfd masks is provided. The NGSO interference is not faded by rain in this analysis.

2. Proposed Evaluation Methodology

2.1 Derivation of Degradation Equations

In this appendix, *noise* in a carrier-to-noise ratio (CNR) refer to the sums of all unwanted powers for a particular situation, such as thermal noise, noise temperature increase from rain, GSO interference, and/or NGSO interference.

The total CNR is affected by uplink and downlink as

$$CNR = \frac{CNR_U \bullet CNR_D}{CNR_U + CNR_D} = \frac{CNR_D}{1 + \frac{CNR_D}{CNR_U}} \tag{1}$$

in which CNR_U and CNR_D are the uplink CNR and the downlink CNR, respectively. In turn, CNR_U is expressed as

$$\begin{aligned} CNR_U &= CNR_{UC} DG_U \\ &= \frac{CNR_{UC}\alpha_U}{1 + \frac{T_{\alpha_U}}{T_U} + \frac{I_{UG} + I_{UN}}{N_U}} \\ &= \frac{CNR_{UC}}{\frac{1}{\alpha_U}\left(1 + \frac{T_{\alpha_U}}{T_U} + \frac{I_{UG} + I_{UN}}{N_U}\right)} \end{aligned} \tag{2}$$

The notations used in Eq. (2) are defined as follows:

CNR_{UC}	carrier-to-noise ratio for uplink in clear sky (T_U only)
DG_U	degradation factor for uplink
$\boldsymbol{\alpha}_U$	rain attenuation in uplink ($0 < \boldsymbol{\alpha}_U < 1$) (a random variable)
$\mathbf{I}_{UN}$	interf. power from NGSO systems in uplink (a random variable)
I_{UG}	interference power received from other GSO systems in uplink
T_{α_U}	noise temperature increase due to rain in uplink
T_U	receive system noise temperature in uplink ($\approx 617°$ K)
N_U	thermal noise power in uplink receiver

$N_U = kT_UB$, where k is the Boltzmann's constant and B is the receiver noise bandwidth. Rain attenuation α_U directly reduces the received carrier power. The denominator of Eq. (2) represents effective noise, relative to T_U, with the inclusion of rain noise temperature and interferences from GSO and NGSO systems. Like the carrier, interferences are attenuated with the factor α_U by rain.

Likewise, the downlink CNR equation is expressed as

$$CNR_D = CNR_{DC} DG_D$$
$$= \frac{CNR_{DC}}{\frac{1}{\alpha_D}\left(1 + \frac{T_{\alpha_D}}{T_D} + \frac{I_{DG} + I_{DN}}{N_D}\right)} \tag{3}$$

where $N_D = kT_DB$. The downlink notations are similarly defined:

CNR_{DC}	carrier-to-noise ratio for downlink in clear sky (T_D only)
DG_D	degradation factor for downlink
$\boldsymbol{\alpha}_D$	rain attenuation in downlink ($0 < \boldsymbol{\alpha}_U < 1$) (a random variable)
$\mathbf{I}_{DN}$	interf. power from NGSO systems in downlink (a random variable)
I_{DG}	interference power received from GSO systems in downlink
T_{α_D}	noise temperature increase due to rain in downlink
T_D	system noise temperature in downlink ($\approx 125°$ K)
N_D	thermal noise power in downlink receiver

The total CNR is therefore

$$CNR = \frac{CNR_{DC}DG_D}{1+\dfrac{CNR_{DC}DG_D}{CNR_{UC}DG_U}}$$

$$= \frac{CNR_{DC}}{\dfrac{1}{\alpha_D}\left(1+\dfrac{T_{\alpha_D}}{T_D}+\dfrac{I_{DG}+I_{DN}}{N_D}\right)}\left[1+\frac{CNR_{DC}}{CNR_{UC}}\bullet\frac{\dfrac{1}{\alpha_U}\left(1+\dfrac{T_{\alpha_U}}{T_U}+\dfrac{I_{UG}+I_{UN}}{N_U}\right)}{\dfrac{1}{\alpha_D}\left(1+\dfrac{T_{\alpha_D}}{T_D}+\dfrac{I_{DG}+I_{DN}}{N_D}\right)}\right]^{-1} \quad (4)$$

Eq. (4) includes "DG", a degradation factor to CNR_{DC}, the downlink CNR in clear sky. Notice that CNR_{DC} is also the performance factor all degradations are evaluated to in Methodology A of Document S. 1323. $DG_U \leq 1$, $DG_D \leq 1$, $DG \leq 1$, and a positive degradation factor in dB is defined as $DG_{dB} = -10\log_{10}(DG) \geq 0$. The degradation factor in Eq. (4) is analytically similar to the one adopted in Document JWP 10-11S/TEMP 41 for the Preliminary Draft New Recommendation, which uses a pdf (probability density function) integration method to calculate the unavailability. The downlink degradation factor DG_D appears twice in the equation but only need be calculated once.

As in Document S.1323, rain and NGSO interference are assumed to occur independently. However, the impact of interference on *degradation* is dependent on rain. Specifically, rain increases system noise temperature and attenuates interference as well as carrier. Therefore, NGSO has a lesser degradation effect in rain than in the clear. This is a major difference between the methodology proposed in this document and Methodology A in Document S. 1323. Since JWP 10-11S/TEMP 41 is based on equations similar to Eq. (4), it also includes the rain-dependent interference effects.

Eq. (4) may be simplified with appropriate approximations. The first approximation ignores everything other than clear-sky thermal noise (N_U) in the uplink. With $\alpha_U = 1$, $T_{\alpha_D} = 0$, and $I_{DN} = I_{DG} = 0$ in Eq. (2), DG_U is found to be 1(no degradation) and thus

$$CNR_U = CNR_{UC}DG_U = CNR_{UC} \quad (5)$$

Eq. (4) is now reduced to

$$CNR = \frac{CNR_{DC}}{\dfrac{1}{\alpha_D}\left(1+\dfrac{T_{\alpha_D}}{T_D}+\dfrac{I_{DG}+I_{DN}}{N_D}\right)}\left[1+\frac{CNR_{DC}}{CNR_{UC}}\bullet\frac{1}{\dfrac{1}{\alpha_D}\left(1+\dfrac{T_{\alpha_D}}{T_D}+\dfrac{I_{DG}+I_{DN}}{N_D}\right)}\right]^{-1} \quad (6)$$

The next approximation goes one step beyond by ignoring the entire uplink in its degradation on the total link. With the reciprocal portion of Eq. (6) set to one, the expression for total CNR is simplified to

$$CNR = \frac{CNR_{DC}}{\frac{1}{\alpha_D}\left(1 + \frac{T_{\alpha_D}}{T_D} + \frac{I_{DG} + I_{DN}}{N_D}\right)} \tag{7}$$

The increase in system noise temperature in Eq. (7) may be evaluated by

$$T_{\alpha_D} = T_{D_m}\left(1 - 10^{\frac{-\alpha_{D\,dB}}{10}}\right) \quad , \tag{8}$$

where T_{Dm} is the rain temperature ($\approx 290^\circ K$) and $\alpha_{dB} = -10\log_{10}(\alpha) \geq 0$ is rain attenuation in dB. Eq. (8) also applies to Eqs. (4) and (6).

The quasi-complete model of Eq. (7) is valid if uplink CNR_U is much higher than downlink CNR_D, which is true in typical situations, particularly when power control is adopted in uplink to offset rain attenuation. However, in arriving at Eq. (7) one should bear in mind the fact that α_U is smaller than α_D due to the higher uplink frequency. The smaller α_U tends to make the reciprocal portion of Eq. (4) less negligible.

The results reported in this document are based on Eq. (7). A mathematical model similar to Eq. (7) was adopted by an analysis spreadsheet provided by JWP 10-11S Special Rapporteur Group 2 with link parameters for many BSS system. However, the epfd of NGSO interference in the SRG-2 spreadsheet is constant and cannot change with time.

Regardless of the approximation in Eq. (7), our results show a close match to those from Document JWP 10-11S/TEMP 41, which is fundamentally based on the more complex expression of Eq. (4) method as mentioned above and which calculates with a pdf integration. In a scenario evaluated for comparison, the pdf Integration method gives an unavailability increase ratio around 11%, while our Monte Carlo method gives an increase ratio around 8.7%. Extension to use of the more complex equations for the Monte Carlo method can be done in a straightforward manner if an increased accuracy for the results is warranted.

As mentioned above, the Monte Carlo method allows rain attenuation and NGSO system interference level to vary with time according to their statistics. All other parameters are assumed constant. The Monte Carlo experiments model the time-varying parameters as random variables to evaluate CNR degradation, such as with Eq. (7). To elaborate, the statistics of system degradation due to rain and NGSO interference are produced with random variables according to their CDFs (cumulative density functions). (In our current version of the simulation algorithm, the CDF for rain is derived from ITU 618-5 with the ITU rain model or the Crane rain model, and the CDF of NGSO is from its epfd mask.) To evaluate Eq. (4), one random variable each is required for uplink rain, uplink NGSO interference (apfd), downlink rain, and downlink NGSO interference (epfd). To evaluate Eq. (6) or (7), two random variables representing downlink rain and NGSO interference suffice.

The complement of the CDF (CDF_C) for a given rain attenuation α_{dB} is related to $A_{0.01}$, the minimum rain attenuation in dB for 0.01% of the time. From ITU 618-5, it is found to be

$$CDF_C(\alpha_{dB}) = 10^{11.628\left[-0.546+\sqrt{0.298+0.172\log_{10}\left(0.12\frac{A_{0.01}}{\alpha_{dB}}\right)}\right]}/100 \qquad (9)$$

which is valid for all CDF_C not exceeding 1%.

For each sample of the random variables independently generated for rain and NGSO interference, the Monte Carlo methodology calculates their combined effect according to the equation (such as Eq. (7)) and arrives at a system degradation value. This process is repeated for a large number of samples. A histogram is built from these degradation values to form a degradation distribution. The distribution is converted to a system availability curve based on the rain degradation characteristics of Eq. (9). The simulation process is repeated for the cases with and without NGSO. Availability reduction caused by the NGSO is calculated by subtracting the unavailability figure without the NGSO from that with the NGSO. The procedure is summarized below:

2.2 Procedure for Monte Carlo Simulation

1. Build a rain impact table with entries in CDF_C vs. rain degradation.
   Also build an NGSO interference impact table with entries in CDF_C vs. interference degradation.
2. Sample a degradation value from the rain table.
   Also sample a degradation value from the NGSO table.
3. Compute the total degradation using Eqs. (7) and (8).
4. Repeat Step 2 for all rain and NGSO samples.
5. Build a histogram of total degradation based on results from Step 3.
6. Repeat Step 1 through 5 for the case with and without NGSO.
   Plot the histograms with and without NGSO.
7. Look up the CDF_C values at the clear-sky margin for the cases with and without NGSO.
8. Compute the increase in unavailability due to NGSO.

Other parameters needed to calculate CNR degradation in Eq. (7) can be derived from the spreadsheet of Annex 3 for a given link scenario. T_D of Eq. (7) is the same as Row 24 or 25 of the spreadsheet. T_{Dm} is 290°K, which is used to compute Row 34. I_{DG}/N_D is calculated by combining C/I_{DG} and C/N_D. Notice that C/I_{DG} is obtained by combining Row 8 and Row 9, and C/N_D is obtained by combining Row 11, Row 12 and C/I_{DG}.

2.3 Discussion of a Sample Simulation Result

Figure 1 shows an example unavailability plot from a Monte Carlo simulation with Eq. (7). The BSS evaluated is a typical system servicing the continental United States. The receive antenna simulated is located in Seattle, Washington, which is in ITU Rain Zone D. The interference mask is the WRC-97 provisional limits for a 45-cm receive antenna.

The horizontal axis of the plot represents the amount of degradation relative to thermal noise (N_D) in dB, and the vertical axis represents time fractions. The staircase represents curve is the complementary cumulative density function (CDF_C) of the provisional epfd limits (or the CDF for the absence of the epfd). The provisional limits are shown to produce 0.25 dB of degradation 99.7% of the time (from I_{DN}/N_D = -12.3 dB) and 1.67 dB of degradation the remaining 0.3% of the time (from I_{DN}/N_D = -3.3 dB).

The two other curves in the plot bear similar shapes. Each curve represents a CDF_C of degradation, i.e., the unavailability as a function of degradation. The time fraction above the curve is the CDF of degradation, or availability as a function of degradation. . Although the rain degradation Eq. (9) is valid only for time fractions not exceeding 1%, it was used to plot all time fractions for convenience. The artificial extension to 100% time fraction does not cause problems to actual results since most unavailabilities of interest are below 1%. The lower curve is without NGSO interference and therefore has smaller unavailability values. The upper curve is for the case when NGSO interference is added.

The long-term portion of the NGSO interference causes an unavailability curve to shift to the right by 0.25 dB at the 100% time fraction. The shift gets smaller as the degradation gets larger. This is because heavier rain attenuation reduces the impact of interference, as discussed above. The shift is the amount of additional carrier power that would be required to offset the long-term interference effect if so required.

Both unavailability curves include a constant GSO interference. The GSO interference causes the CDF_C curves to start at approximately 0.28 dB at the 100% time fraction. The 0.28 dB degradation value comes from an I_{DG}/N_D of –11.8 dB.

The "blip" on the upper curve is caused by short-term interference. The time fraction at the blip is approximately the sum of the time fractions for rain and NGSO interference at the degradation level. (Since rain and interference are both of low probability at this degradation level, the probability of having either of them is the sum of the two probabilities.) The blip has been right-shifted from the short-term degradation value by 0.28 dB due to *constant* GSO interference as mentioned above. As one moves away from the blip to the right on the curve with the presence of NGSO, the unavailability time fraction drops rapidly toward the NGSO-free curve. Therefore, providing a small margin beyond the blip will ensure a relatively benign increase in system unavailability caused by NGSO. These factors were considered when designing the epfd masks discussed in the main text of this document.

The vertical bar at the 3.9-dB degradation represents the system clear sky margin (CSM) before including the effects of adjacent GSO BSS interference, adjacent GSO FSS interference, and uplink effects. System unavailabilities are read off the two curves at this point. The difference between the two values at the CSM is the unavailability increase due to NGSO. The unavailability increase ratio is the unavailability increase divided by the unavailability without NGSO. The example plot of Figure 1 shows an increase ratio of approximately 8.7%. Notice that the smallest and largest tic intervals on the vertical logarithmic scale represent 10% and 100% increases of unavailability, respectively.

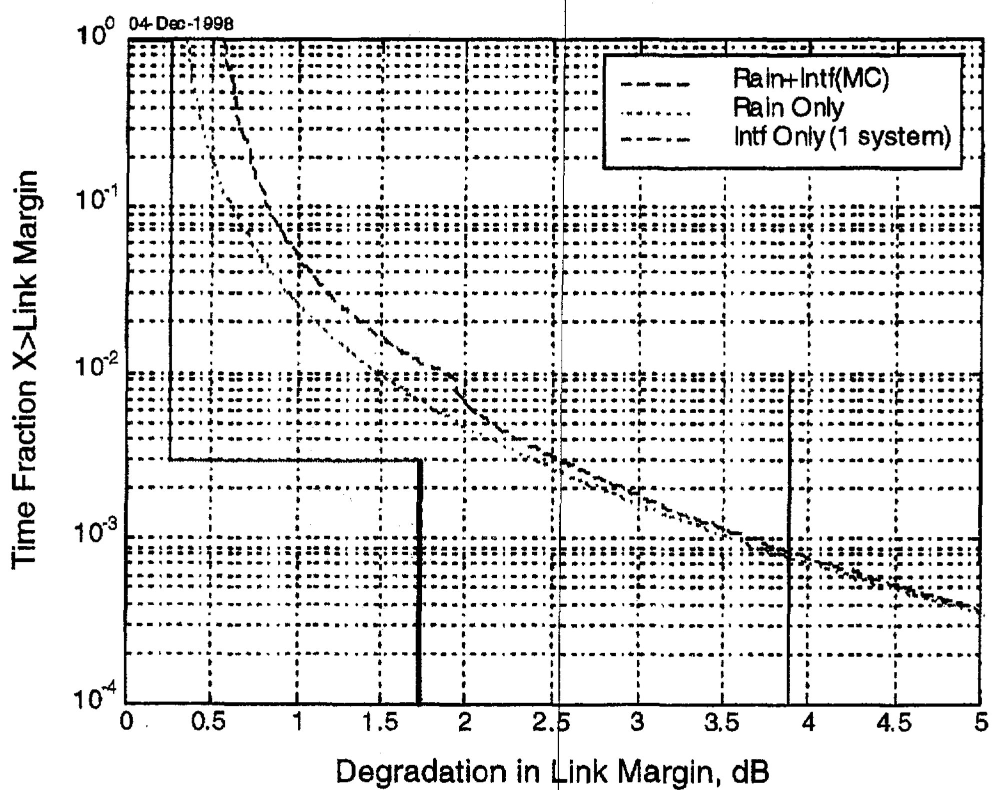

Figure 1. Example Unavailability Plot

2.4 Slope of Regime B in Proposed epfd Masks

The slope of Regime B in the proposed masks is derived from the earth station receive antenna mask which is defined by Equation 8 of Annex 5 in Appendix 30 for Region 2. The slope of the Appendix 30 mask beyond the antenna mainlobe is 7.5 dB per octave (from $25\log_{10}\theta$) along any radial direction. For reference purposes, this constant-slope extends roughly from 4.5° to 55° off the boresight of a 45-cm antenna. Assume that an NGSO satellite is equally likely to be anywhere within an angular field of view of the receive antenna. The probability of the antenna receiving NGSO interference within a conical angle that has a diameter twice as wide is four times. This means that the probability that the antenna will receive NGSO interference that is 7.5 dB lower will be four times. This translates to a 10 times probability for the antenna to receive an interference which is 11.5 dB lower ($11.5 = -7.5 - 10\log_{10}(10/4)$). Thus the slope of Regime B is 11.5 dB per decade.

As the angle from the receive antenna boresight gets larger, the above relationship becomes non-linear in dB. At the same time, the antenna mask Appendix 30 reaches a floor of –43.2 dB beyond 55° for a 45-cm antenna. These factors make the epfd slope for this region much steeper and provide a rationale for the vertical line in Regime C in the recommended epfd masks.

B

TECHNICAL APPENDIX B:

ANALYSIS OF BSS-NORTHPOINT INTERFERENCE ISSUES

DIRECTV, INC.

March 2, 1999

1 OVERVIEW: PROPOSED SPECTRUM POLICY FOR PROTECTING BSS OPERATIONS FROM NORTHPOINT'S TERRESTRIAL OPERATIONS

The BSS service has been allocated use of the 12.2-12.7 GHz band on a primary basis, both domestically and internationally, for service downlinks. Although BSS systems(known as Direct Broadcast Satellite ("DBS") systems in the United States) only became operational in the United States in 1994, BSS already has more than 8 million U.S. subscribers. The Commission has declared the service the "single largest competitor to cable operators" and the service "continues to show strong growth."[1]

Northpoint has proposed to use BSS downlink frequencies to offer a terrestrial service to subscribers on a nationwide basis. For nearly two decades, the Commission has worked to transition terrestrial point-to-point licensees *out* of the 12 GHz band, explicitly recognizing the interference threat that such licensees pose to BSS service even when operating on a secondary basis.[2] As a proposed direct competitor to DIRECTV using DIRECTV's own frequencies, Northpoint has little incentive to mitigate harmful interference from its terrestrial operations.

More fundamentally, DIRECTV has studied the Northpoint system, cooperated with Northpoint's experimental operations, and examined Northpoint's experimental data. As explained below, DIRECTV has concluded that the proposed Northpoint operations pose a grave interference threat to the quality of service that U.S. DBS operators provide to consumers. The following technical and policy conclusions flow from DIRECTV's analysis of Northpoint's proposed terrestrial operations:

1. **The 12 GHz band cannot accommodate additional interference sources without seriously jeopardizing BSS operations.** BSS is already contending with proposed NGSO entrants. Work in the international arena is settling on an aggregate interference allocation for NGSO systems equivalent to a 10% degradation in unavailability. In addition, BSS systems in the U.S. may need to contend with added interference from foreign administrations providing service to the U.S. from their BSS orbital assignments. Already confronted with significant challenges from multiple interference sources, authorizing a terrestrial service on a nationwide basis such as the one Northpoint proposes would be disastrous to the further development and growth of BSS.

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1 *Annual Assessment of the Status of Competition in Markets for the Delivery of Video Programming*, CS Docket No. 98-102 (rel. Dec. 23, 1998), at 62.

2 *See, e.g.*, Public Notice, *Initiation of Direct Broadcast Satellite Service -- Effect on 12 GHz Terrestrial Point-to-Point Licensees in the Private Operational Fixed Service*, 10 FCC Rcd 1211 (1994) (explicitly reminding remaining 12 GHz terrestrial licensees of their secondary status, and stating that "[i]n view of the imminent arrival of DBS service, terrestrial 12 GHz licensees should again consider relocating their operations to other available frequency bands or alternative facilities").

2. **No more terrestrial licenses should be granted at 12.2-12.7 GHz, even on a secondary basis.** For the same reasons, the Commission should not consider introducing more sources of terrestrial interference into the 12 GHz band, even on a secondary basis. As the Commission recognized (and reminded the terrestrial user community) when DBS service became a reality in 1994, "[r]eaccomodation of existing 12 GHz users" was deemed necessary by the Commission when BSS/DBS was first authorized "because of the likelihood of interference that terrestrial use would cause to DBS service if both were operating in the same geographic area."[3]

3. **The Commission cannot allow even one Northpoint-like system into the 12 GHz band**. This is because:

> a. If one Northpoint system is granted an interference allocation equivalent to one NGSO system, then this will necessarily reduce the overall NGSO use of this band segment by one NGSO system. An aggregate interference cap is necessary to protect the BSS from both NGSO systems and Northpoint. To maintain such a cap, adding interference to accommodate one Northpoint system reduces by one the number of NGSO systems that can ultimately be deployed.
>
> b. At an interference allocation equivalent to one NGSO system, the Northpoint system becomes untenable. Using calculations based on previously submitted technical data by Northpoint, the zone around a Northpoint transmitter where the interference level exceeds the international criteria noted above occupies *more than 50% of the proposed service area.* This is clearly unacceptable, especially when one considers that Northpoint proposes to deploy this system in all major metropolitan centers throughout the United States.

Section 2 of this Appendix will develop a protection criterion for this sharing situation that is wholly consistent with extensive work that has been done in the international technical arena concerning sharing with NGSO FSS systems. Section 2 then proceeds to determine the required separation distance between the proposed Northpoint transmitters and any BSS receiver to meet this sharing criterion. Section 2 shows that the required separation distance is so large that the Northpoint system is clearly untenable, and any mitigation steps would negate the true benefits of DBS service.

Section 3 analyzes the experimental test data provided by Northpoint in its January 20, 1999 experimental progress report concerning the Austin, Texas tests. Although DIRECTV has serious reservations about the methodology and test methods used in this test, there is direct evidence given in the experimental progress report that the Northpoint transmitter directly and seriously caused harmful interference with BSS receiver operations throughout the Austin, Texas area. This harmful interference, *as documented by Northpoint*, occurred at 28 of the 29 test sites.

Specifically, the harmful interference manifested itself in the Austin tests as a serious degradation in clear sky margin, which increases the stress on the satellite receiver front-

3 *Id.* at 1.

end error correction circuitry. As calculations in Section 3 will show, this directly results in unacceptably large increases in signal unavailability during rain fade conditions, which directly harms DBS subscribers in reduction of delivered service quality.[4]

2 INTERFERENCE ANALYSIS: GSO BSS AND NORTHPOINT

DIRECTV has conducted a careful analysis of the potential for co-existence of BSS and Northpoint's proposed service at 12 GHz, which is described in detail below. In this analysis, the Northpoint system is allocated the equivalent harmful impact of one NGSO system on BSS overall signal unavailability, which is 1/5 of the aggregate interference allowance. As derived below, this criterion allows the Northpoint system to degrade DBS signal unavailability by no more than 2%. This is a reasonable and equitable criterion because:

- the preliminary draft new recommendation (PDNR) approved by Working Party 10-11S at its October 1998 meeting established important precedents for inter-service sharing;
- this criterion allocates an equal amount of the inter-service interference budget specified in the PDNR to each inter-service system, whether it is one NGSO FSS system or one Northpoint system;
- this criterion does not exclude NGSO systems.

First, the link budget previously supplied by Northpoint in the Technical Annex to the Reply Comments of Northpoint Technology, filed May 5, 1998,[5] is analyzed, and then adjusted for the purposes of interference analysis (certain incorrect assumptions were made by Northpoint in this budget and they must be adjusted). Second, using one of the internationally accepted and important BSS link budgets currently being evaluated within ITU-R Joint Task Group ("JTG") 4-9-11 for service to the United States, we then calculate the maximum received isotropic signal strength (RSSi) that would be required to meet the sharing criterion stated above. DIRECTV shows that this signal strength is exceeded for at least 50% of the proposed Northpoint service area, rendering such service untenable. Finally, DIRECTV addresses the inability of the proposed Northpoint mitigation techniques to alleviate this situation (that is, by increasing tower height or by tilting the transmit beam).

2.1 Development of a Reference Northpoint Link Budget

The Northpoint link budget presented in the Northpoint Technical Annex, when used for interference analysis, is flawed in several important respects. This link budget from Table A-1 of Northpoint's Technical Annex is reproduced in Figure 2.1-1 below.

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[4] DIRECTV reserves the right to offer additional comment on this data, which was only recently obtained from Commission files.

[5] Bob Combs and Associates, Technical Annex to Reply Comments of Northpoint Technology (May 5, 1998)("Northpoint Technical Annex").

From Table A-1 in the Northpoint Technical Annex						
Line	Units	Source/Calculation	Item	Symbol	Value	Corrected Value
1	MHz		Channel Bandwidth	B	24.0	
2	GHz		Frequency	f	12.5	
3	%		Availability		99.7%	
4	dBW		Transmit Power	P	-25.0	
5	Watts		Transmit Power	p	0.003	
6	dB		Line Losses	Ll	-2.5	
7	dBi		Transmit Gain	Gt	10.0	
8	dBW	P+Ll+Gt	EIRP	EIRP	-17.5	
9	dBm		EIRP (dBm)	EIRPdBm	12.5	
10	km		Path Length	D	16.0	
11	dB	-114.3 - 20*log(D)	Path Loss	Pl	-138.4	
12	dB		Fade Margin	FM	-2.0	0.0
13	dB		Atmos	Atmos	-0.1	
14	dB		Rain Margin	Rain	-1.5	0.0
15	dBW	EIRP+Pl+Fm+Atmos+Rain	RSSi	Rssi	-159.5	
16	dBm		Isotropic RSS (dBm)	RSSi dBm	-129.5	
17	dBi	45 cm antenna	Receive Antenna Gain	Gt	34.0	
18	dB		Pointing Loss	Ploss	-0.5	
19	dBW	RSSi+G+Ploss	C Received	Crec	-126.0	
20						
21	degrees K		System Temp	t	120.0	
22	dB-K	10*log(t)	System Temp	T	20.8	
23	dB/K	G-10*log(t)	G/T	G/T	13.2	
24	dB/K	Constant	Boltzmans	k	-228.6	
25	dB	k+10*log(TB*10e6)	Noise Figure kTB	N	-134.0	
26						
27	dB	C-N	Theoretical C/N Received	C/N	8.0	
28	dB	QPSK at 10e-04 BER	C/N Required	C/Nreq	8.0	
29	dB	C/N-C/Nreq	System Margin	Margin	0.0	

Figure 2.1-1 Table from Northpoint Technical Annex (including values for erroneously defined "Fade Margin" and "Rain Margin" terms)

First, this link budget includes an attenuation term for rain, called "Rain Margin." This is not the accepted treatment of this effect for interference calculations, as shown in the column labeled "Corrected Value." Rain fade attenuation, when applied over a wide range of space, is not uniform. The worst case situation occurs when the transmission path from the BSS satellite down to the BSS receiver is attenuated by a heavy rain cell. The interference path from the Northpoint transmitter to the BSS receiver has significantly less attenuation or no attenuation at all. It is because of this very situation that JTG 4-9-11 decided at the Long Beach meeting *not* to fade the interfering signal when considering interference effects on the unavailability performance of the desired signal.

Second, the link budget contains a term called "Fade Margin." DIRECTV assumes that this term is an estimate of the amount of variation that can be expected in the Northpoint signal at any point in the service area due to multipath effects. For inclusion in an interference budget, this term should be at best taken as 0 dB (as shown in the column labeled "Corrected Value") although a true worst case analysis would treat this as a signal additive term. Northpoint presents this as a signal reduction term, which from an interference standpoint, is the best case over the service area, not the worst case, and is clearly incorrect (interestingly, Northpoint's own test data described later shows that this can be an additive term as high as 13.3 dB). The analysis performed below assumes that there is no multipath (fade margin set to 0 dB), but if this term is taken as being greater than zero, the size of the high interference zone will increase, and in some cases, dramatically so. This is an important point. The analysis that follows is really a lower bound on the interference levels. High multipath levels can and will cause areas of high interference *throughout the service area.*

Reconstructing the data shown in Figure 2-1 of the Northpoint Technical Annex indicates that the values for the parameters noted above had not been set to zero in the Northpoint provided calculations. The impact of this error is to raise the RSSi curves in Figures 2-1, 2-2, 2-3, and 2-4 of the Northpoint Technical Annex by 3.5 dB.

DIRECTV then used the vertical gain pattern for the Northpoint antenna presented in the Engineering Exhibit to the Reply Comments of Northpoint prepared by Delawder Communications, Inc., to recreate the graph shown in Figure 2-4 of the Northpoint Technical Annex. As shown in Figure 2.1-2 below, the corrected curve is now 3.5 dB higher than the data presented in Figure 2-4 of the Northpoint Technical Annex.

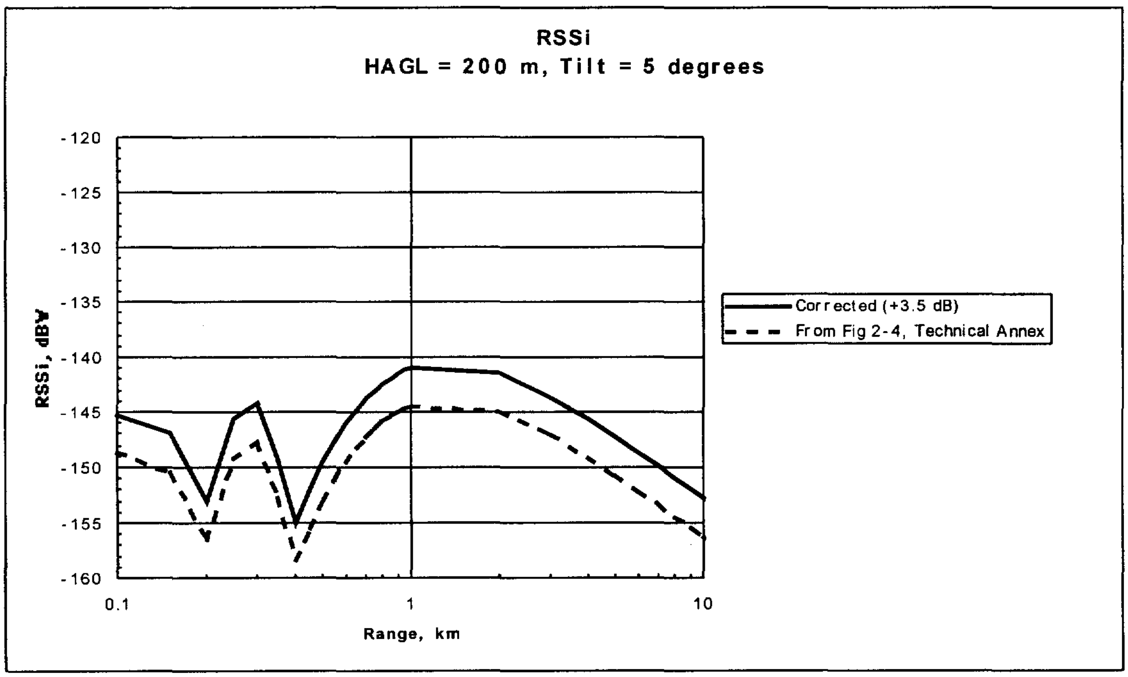

Figure 2.1-2 DIRECTV corrected graph of RSSi versus range (calculated using a Northpoint transmitter tower height of 200 m and an antenna tilt of 5 degrees).

2.2 Establishment of an Appropriate Sharing Criterion

Northpoint has proposed that appropriate sharing criterion between its service and BSS service be established at a C/I ratio of 20 dB. This value, however, is clearly inadequate for the protection of the BSS as described below.

2.2.1 Protection Equivalent to one NGSO FSS System

ITU-R Joint Working Party ("JWP") 10-11S agreed on a preliminary draft new recommendation at its October 1998 meeting in Geneva, Switzerland, which addressed protection criteria for sharing between NGSO FSS systems and the BSS. JWP 10-11S decided that an appropriate protection criterion for this situation is to limit the amount of degradation allowed in BSS link unavailability, accounting for all NGSO FSS interference sources, to 10%. If one assumes that a reasonable upper bound on the equivalent number of NGSO FSS systems that can be accommodated in a single band is 5, then each NGSO FSS system would be allowed to increase the unavailability of a BSS link by 2%. This 2% increase is then applied to Northpoint as an equivalent single-entry inter-service sharing criterion.

The C/I for a 2% increase in unavailability can be calculated using BSS link budgets. The link US-GSO 1(a) shown in Table 2.2.1-1 below describes BSS service to the north-western United States using a digital transmission system which requires C/N = 5 dB for acceptable service quality. This and other BSS links were prepared in support of ITU-R JTG 4-9-11 which is investigating the impact of NGSO FSS interference on GSO BSS and GSO FSS systems. As calculated in Table 2.2.1-1, the clear sky C/N for this link is 8.9 dB. This is significantly lower than the clear sky C/N values of 11 to 15 dB mentioned on page 24 of the Northpoint Technical Annex.

If Northpoint is allowed to degrade the unavailability of this BSS link by 2%, the C/I is calculated to be 28.6 dB. This calculation, shown in Table 2.2.1-2, is performed by replacing the term "C/I due to GSO FSS" in Table 2.2.1-1 by a term which represents interference from Northpoint. Since the interference should not be faded by rain, per agreements reached during the January 1999 JTG 4-9-11 meeting, line 16 shows that a clear sky C/I value of 28.6 dB is required to limit the impact of the Northpoint link to a 2% increase in unavailability. This is shown in the last column in Table 2.2.1-2.

The conclusion from this analysis is that the C/I to be used for this link is 28.6 dB and not the C/I value of 20 dB as reported in Northpoint's Technical Annex. If the total number of NGSO systems is more than five, the interference allowance per NGSO FSS system and per Northpoint system would be reduced accordingly.

Table 2.2.1-1 Link US-GSO 1(a) presented in ITU Joint Task Group 4-9-11

		USA
BSS Assignment characteristics	**Units**	**US-GSO 1(a)**
System Characteristics		
Frequency	GHz	12.700
Availability objective	%	99.92
Calculated availability due to rain up and downlink (Rec P 618-5)	%	
Calculated availability due to rain downlink (Rec P 618-5)	%	
Calculated availability due to rain uplink (Rec P 618-5)	%	
Receiver noise Bandwidth	MHz	24
Modulation type		QPSK
C/I due to other GSO BSS networks	dB	20.7
C/I due to GSO FSS networks	dB	99
Clear sky feeder link C/N+I	*dB*	*24.2*
C/N+I required at operating threshold	dB	5.0
Clear sky C/N+I margin above operating threshold (1)	dB	3.6
Total Clear sky C/N+I margin above operating threshold (1)	dB	
Available clear sky downlink rain margin above threshold	dB	
Available clear sky uplink rain margin above threshold	dB	
C/N+I total link for 99.7% of the time	dB	
C/N+I margin above operating threshold for 99.7% of the time	dB	1.5
C/N+I total link margin above operating threshold for 99.7% of the time	dB	
Space station characteristics		
Longitude	°	101W
Satellite e.i.r.p. in the direction of the earth station	dBW	48
Earth station characteristics		
Receive antenna diameter	cm	45
Receive antenna efficiency	%	*70*
On-axis antenna gain at receiver input	dBi	34
On-axis antenna gain at antenna output	**dBi**	
Off-axis antenna gain characteristics		App 30, An. 5
Clear sky receive system noise temperature at receiver input	K	125
Clear sky receive system noise temperature at antenna output	K	
Clear sky G/T	*dB/K*	*13*
Total pointing loss	dB	0.5
Location of earth station		
Latitude	°	47.6
Longitude	°	122.3W
Altitude	km	
Rain climatic zone		D
Elevation angle	°	31.5
Propagation characteristics		
Slant path	*km*	*38500*
Free space loss	*dB*	*206.2*
Atmospheric absorption	*dB*	*0.2*
Rain attenuation for 99.7% of the time	dB	0.80
Noise increase due to rain for 99.7 % of the time	*dB*	*1.4*
Wanted pfd received at earth station	dB(W/m2)	
Rain attenuation for availability percentage of time	dB	1.50
Noise increase due to rain for availability percentage of time	*dB*	*2.2*
Downlink budget clear sky		
C/N thermal clear sky downlink	*dB*	*8.9*
C/N+I clear sky downlink	*dB*	*8.6*
C/N+I clear sky total link	*dB*	*8.5*
Clear sky C/N downlink margin above operating threshold	dB	3.9
Clear sky C/N+I downlink margin above operating threshold	dB	3.6
Clear sky C/N+I total margin above operating threshold	dB	3.5
Downlink budget 99.7% of the time		
C/N thermal for 99.7% of the time, downlink	*dB*	*6.7*
C/N+I for 99.7% of the time, downlink	*dB*	*6.5*
C/N margin above operating threshold for 99.7% of the time, downlink	dB	1.7
C/N+I margin above operating threshold for 99.7% of the time, downlink	dB	1.5
Downlink budget for availability percentage of time		
C/N thermal for availability percentage of time, downlink	*dB*	*5.2*
C/N+I for availability percentage of time, downlink	*dB*	*5.0*
C/N margin above operating threshold for availability percentage of the time, do	dB	0.2
C/N+I margin above operating threshold for availability percentage of the time,	dB	0.0
Feeder link earth station characteristics		
Frequency	GHz	17.7
Maximum uplink power control		
Minimum feeder link earth station eirp	dBW	78.0
Latitude	°	39.7
Longitude	°	105.0
Altitude	km	
Rain climatic zone		E
Elevation angle	°	43.8
Rain attenuation for 99.97% of the time	dB	3.00
Rain attenuation for availability percentage of time	dB	
Characteristics of the space station receiver		
Satellite receive noise temperature	K	616.6
Satellite receive antenna gain in the direction of the feeder link station	dB	32.2
Automatic gain control setting		
C/I due to other GSO BSS networks	dB	30.0
C/I from other assignments in the Plan	dB	
C/I from other GSO FSS systems	dB	30.0
Uplink budget		
Atmospheric absorption	*dB*	*0.5*
Slant path	*km*	*38500*
Free space loss	*dB*	*209.1*
C/N thermal clear sky	*dB*	*27.5*
C/N+I clear sky	dB	24.2
C/N thermal uplink for 99.97% of the time	dB	
C/N+I uplink for 99.97% of the time	dB	
Available clear sky uplink rain margin above threshold	dB	

Footnote 1: For US-GSO D5, rain effects are not relevant.
Footnote 2: See the antenna gain pattern mask in attachment 1 to document 4-9-11/165 Corr.1
Footnote 3: See "test results template" in Figure 4 of ITU Document 4-9-11/172-E, 25 June 1998.

Table 2.2.1-2 Calculation of C/I to be used for interference analysis

1			No Northpoint Interference	With Northpoint Interference
2	**BSS Assignment characteristics**	**Units**	**US-GSO 1(a)**	**US-GSO 1(a)**
3	**System Characteristics**			
4	Frequency	GHz	12.700	12.700
5	Availability objective	%	99.9228	99.9212
6	Outage Hours		6.77	6.90
7	Increase in outage hours			0.14
8	Percentage increase in unavailability			2.0%
9	Calculated availability due to rain up and downlink (Rec P 618-5)	%		
10	Calculated availability due to rain downlink (Rec P 618-5)	%		
11	Calculated availability due to rain uplink (Rec P 618-5)	%		
12	Receiver noise Bandwidth	MHz	24	24
13	Modulation type		QPSK	QPSK
14	C/I due to other GSO BSS networks	dB	20.7	20.7
15	C(faded)/I(faded) due to NorthPoint required for Percentage increase in unavailability	dB	99	27.1
16	Clear sky C/I due to NorthPoint required for Percentage increase in unavailability			28.6
17	*Clear sky feeder link C/N+I*	*dB*	*24.2*	*24.2*
18	C/N+I required at operating threshold	dB	5.0	5.0
19	Clear sky C/N+I margin above operating threshold (1)	dB	3.6	3.6
20	Total Clear sky C/N+I margin above operating threshold (1)	dB		
21	Available clear sky downlink rain margin above threshold	dB		
22	Available clear sky uplink rain margin above threshold	dB		
23	C/N+I total link for 99.7% of the time	dB		
24	C/N+I margin above operating threshold for 99.7% of the time	dB	1.5	1.5
25	C/N+I total link margin above operating threshold for 99.7% of the time	dB		
26	**Space station characteristics**			
27	Longitude	°	101W	101W
28	Satellite e.i.r.p. in the direction of the earth station	dBW	48	48
29	**Earth station characteristics**			
30	Receive antenna diameter	cm	45	45
31	*Receive antenna efficiency*	*%*	*70*	*70*
32	On-axis antenna gain at receiver input	dBi	34	34
33	**On-axis antenna gain at antenna output**	**dBi**		
34	Off-axis antenna gain characteristics		App 30, An. 5	App 30, An. 5
35	Clear sky receive system noise temperature at receiver input	K	125	125
36	Clear sky receive system noise temperature at antenna output	K		
37	*Clear sky G/T*	*dB/K*	*13*	*13*
38	Total pointing loss	dB	0.5	0.5
39	Location of earth station			
40	Latitude	°	47.6	47.6
41	Longitude	°	122.3W	122.3W
42	Altitude	km		
43	Rain climatic zone		D	D
44	Elevation angle	°	31.5	31.5
45	**Propagation characteristics**			
46	*Slant path*	*km*	*38500*	*38500*
47	*Free space loss*	*dB*	*206.2*	*206.2*
48	*Atmospheric absorption*	*dB*	*0.2*	*0.2*
49	Rain attenuation for 99.7% of the time	dB	0.80	0.80
50	*Noise increase due to rain for 99.7 % of the time*	*dB*	*1.4*	*1.4*
51	Wanted pfd received at earth station	dB(W/m2)		
52	Rain attenuation for availability percentage of time	dB	1.52	1.50
53	*Noise increase due to rain for availability percentage of time*	*dB*	*2.3*	*2.3*
54	**Downlink budget clear sky**			
55	*C/N thermal clear sky downlink*	*dB*	*8.9*	*8.9*
56	*C/N+I clear sky downlink*	*dB*	*8.6*	*8.6*
57	*C/N+I clear sky total link*	*dB*	*8.5*	*8.4*
58	Clear sky C/N downlink margin above operating threshold	dB	3.9	3.9
59	Clear sky C/N+I downlink margin above operating threshold	dB	3.6	3.6
60	Clear sky C/N+I total margin above operating threshold	dB	3.5	3.4
61	**Downlink budget for availability percentage of time**			
62	*C/N thermal for availability percentage of time, downlink*	*dB*	*5.1*	*5.1*
63	*C/N+I for availability percentage of time, downlink*	*dB*	*5.0*	*5.0*
64	C/N margin above operating threshold for availability percentage of the time, downlink	dB	0.1	0.1
65	C/N+I margin above operating threshold for availability percentage of the time, downlink	dB	0.00	0.00

2.2.2 Determination of Maximum Allowable Received Isotropic Signal Strength (RSSi)

It is very important that the separation distance calculation between the Northpoint transmitter and a BSS receiver be generalized so that all reasonable pointing directions of the BSS receive antenna are accounted for. That is, reception from all reasonable points on the geostationary arc must be taken into account.

Table 2.2.2-1 shows calculations performed to determine BSS receive antenna gain for the general case of BSS antennas receiving transmissions from satellites anywhere in the geostationary arc, where these satellites are present at a minimum 9° elevation angle. This calculation is very similar to that described in Appendix 1 to Annex 1 of ITU-R Recommendation IS.847, Titled "Determination Of The Coordination Area Of An Earth Station Operating With A Geostationary Space Station And Using The Same Frequency Band As A System In A Terrestrial Service." Instead of calculating the off-axis angle as indicated in this Recommendation, actual BSS horizon gain is calculated using a reference horizon gain pattern. The horizon gain is calculated as a function of the latitude difference between the earth station and the desired BSS space station, and as a function of the azimuth angle from the BSS user terminal to the Northpoint transmitter. One hundred eighty degrees of azimuth indicates that the Northpoint transmitter is due north of the BSS user terminal. From the last column in Table 2.2.2-1, the peak gain for all Northpoint-BSS earth station geometries is seen to be -2 dBi, with only one point at -4 dBi.

However, recent measurements reported to JTG 4-9-11 by Canada in document JTG4-9-11/356 demonstrate that much higher sidelobe levels can be expected for 45-cm antennas in planes other than the horizontal plane (see plate 2 on page 7 of document JTG4-9-11/356 which shows a peak sidelobe level of about 3 dBi). These sidelobes become important if the Northpoint transmitting antenna is mounted above ground level. Additionally, the data used to generate the BSS reference horizon gain pattern was based on one measured antenna pattern. Variations between individual antennas are observed. For these reasons, a value of 0 dBi is used for the BSS earth station horizon gain in the following discussions.

Table 2.2.2-1 DIRECTV calculation of BSS earth station receive antenna horizon gain

			Difference in Longitude, Degrees																										
	-65	-60	-55	-50	-45	-40	-35	-30	-25	-20	-15	-10	-5	-1	1	5	10	15	20	25	30	35	40	45	50	55	60	65	
Great Circle, radians	1.267	1.209	1.153	1.099	1.047	0.998	0.953	0.912	0.875	0.844	0.819	0.800	0.789	0.786	0.786	0.789	0.800	0.819	0.844	0.875	0.912	0.953	0.998	1.047	1.099	1.153	1.209	1.267	
Sat El Angle, degrees	8.8	12.2	15.6	18.8	21.9	24.9	27.7	30.3	32.5	34.5	36.1	37.2	37.9	38.2	38.2	37.9	37.2	36.1	34.5	32.5	30.3	27.7	24.9	21.9	18.8	15.6	12.2	8.8	
Sat Az Angle, degrees	108.2	112.2	116.3	120.7	125.3	130.1	135.3	140.8	146.6	152.8	159.2	166.0	172.9	178.6	178.6	172.9	166.0	159.2	152.8	146.6	140.8	135.3	130.1	125.3	120.7	116.3	112.2	108.2	
NPT to BSS ES Az Angle deg																	BSS Rcv Antenna Gain (Horizon)												Maximum Gain
60	-12	-12	-12	-14	-14	-14	-12	-12	-14	-14	-16	-16	-10	-10	-10	-10	-10	-10	-9	-9	-7	-7	-6	-6	-6	-4	-4	-4	-4
70	-12	-14	-14	-14	-12	-12	-14	-14	-16	-16	-10	-10	-10	-10	-10	-10	-9	-9	-7	-7	-6	-6	-6	-4	-4	-2	-2	-2	-2
80	-14	-12	-12	-12	-14	-14	-14	-16	-16	-10	-10	-10	-10	-10	-10	-9	-9	-7	-7	-6	-6	-4	-4	-2	-2	-2	-12	-12	-2
90	-12	-12	-14	-14	-14	-16	-16	-10	-10	-10	-10	-10	-10	-9	-9	-7	-7	-6	-6	-4	-4	-2	-2	-12	-12	-12	-16	-16	-2
100	-14	-14	-16	-16	-16	-10	-10	-10	-10	-10	-10	-9	-9	-7	-7	-7	-6	-4	-4	-2	-2	-12	-12	-12	-16	-16	-16	-16	-2
110	-16	-16	-16	-10	-10	-10	-10	-10	-10	-10	-9	-9	-7	-6	-6	-6	-4	-4	-2	-2	-12	-12	-16	-16	-16	-16	-16	-12	-2
120	-10	-10	-10	-10	-10	-10	-10	-10	-9	-9	-7	-7	-6	-6	-4	-4	-2	-2	-12	-12	-16	-16	-16	-16	-16	-12	-12	-12	-2
130	-10	-10	-10	-10	-10	-10	-9	-9	-7	-7	-6	-6	-4	-4	-4	-2	-12	-12	-16	-16	-16	-16	-16	-12	-12	-16	-16	-16	-2
140	-10	-10	-10	-10	-9	-9	-9	-7	-7	-6	-6	-4	-2	-2	-2	-12	-12	-16	-16	-16	-16	-12	-12	-16	-16	-16	-16	-16	-2
150	-10	-10	-9	-9	-9	-7	-7	-6	-6	-4	-4	-2	-2	-12	-12	-16	-16	-16	-16	-12	-12	-16	-16	-16	-16	-16	-12	-12	-2
160	-9	-9	-7	-7	-7	-6	-6	-4	-4	-2	-2	-12	-12	-16	-16	-16	-16	-12	-12	-16	-16	-16	-16	-16	-12	-12	-12	-2	-2
170	-7	-7	-7	-6	-6	-4	-4	-4	-2	-2	-12	-12	-16	-16	-16	-16	-12	-12	-16	-16	-16	-16	-12	-12	-2	-2	-2	-4	-2
180	-6	-6	-6	-4	-4	-4	-2	-2	-12	-12	-16	-16	-16	-16	-12	-12	-16	-16	-16	-16	-12	-12	-2	-2	-2	-4	-4	-4	-2
190	-6	-4	-4	-4	-2	-2	-12	-12	-16	-16	-16	-16	-12	-12	-12	-16	-16	-16	-12	-12	-2	-2	-2	-4	-4	-6	-6	-6	-2
200	-4	-2	-2	-2	-12	-12	-12	-16	-16	-16	-16	-12	-16	-16	-16	-16	-16	-12	-12	-2	-2	-4	-4	-6	-6	-6	-7	-7	-2
210	-2	-2	-12	-12	-12	-16	-16	-16	-16	-12	-12	-16	-16	-16	-16	-12	-12	-2	-2	-4	-4	-6	-6	-7	-7	-7	-9	-9	-2
220	-12	-12	-16	-16	-16	-16	-16	-12	-12	-16	-16	-16	-16	-12	-12	-12	-2	-4	-4	-6	-6	-7	-7	-7	-9	-9	-9	-10	-2
230	-16	-16	-16	-16	-16	-12	-12	-12	-16	-16	-16	-16	-12	-2	-2	-2	-4	-4	-6	-6	-7	-7	-9	-9	-10	-10	-10	-10	-2
240	-16	-16	-16	-12	-12	-12	-16	-16	-16	-16	-12	-12	-2	-2	-4	-4	-6	-6	-7	-7	-9	-9	-10	-10	-10	-10	-10	-10	-2
250	-16	-12	-12	-12	-16	-16	-16	-16	-12	-12	-2	-2	-4	-4	-4	-6	-7	-7	-9	-9	-10	-10	-10	-10	-10	-10	-10	-10	-2
260	-12	-16	-16	-16	-16	-16	-16	-12	-12	-2	-2	-4	-6	-6	-6	-7	-7	-9	-9	-10	-10	-10	-10	-10	-10	-10	-16	-16	-2
270	-16	-16	-16	-16	-16	-12	-12	-2	-2	-4	-4	-6	-6	-7	-7	-9	-9	-10	-10	-10	-10	-10	-10	-16	-16	-16	-14	-14	-2
280	-16	-16	-12	-12	-12	-2	-2	-4	-4	-6	-6	-7	-7	-9	-9	-9	-10	-10	-10	-10	-10	-16	-16	-16	-14	-14	-14	-12	-2
290	-12	-12	-12	-2	-2	-4	-4	-4	-6	-6	-7	-7	-9	-10	-10	-10	-10	-10	-10	-10	-16	-16	-14	-14	-12	-12	-12	-14	-2
300	-2	-2	-2	-4	-4	-4	-6	-6	-7	-7	-9	-9	-10	-10	-10	-10	-10	-10	-16	-16	-14	-14	-12	-12	-12	-14	-14	-14	-2

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To determine the values of RSSi for which Northpoint would introduce unacceptable interference into a BSS system, C/I = 28.6 dB can be used in Table A-2 of the Technical Annex to the Reply Comments of Northpoint. Table 2.2.2-2 reproduces the original calculation from Table A-2, and then repeats the calculation using the correct C/I and C/N values for US-GSO 1(a), and adds a term for atmospheric absorption in the BSS link. The value for "Allowable RSSi" for Northpoint is now -154.2 dB rather than the -142.9 dB that was calculated in the Technical Annex. The revised value for RSSi is more than 10 dB lower than the worst case RSSi cited in the Northpoint Technical Annex (with 0-dBi BSS earth station horizon gain).

			From Northpoint Technical Annex	US-GSO 1(a) with 0 dB earth antenna station gain toward Northpoint transmitter
Line	Units	Item	Value	Value
1	GHz	Frequency	12.5	12.5
2	dB	DBS Clear Sky C/N(thermal)	11.4	8.9
2	dB/K	DBS G/T	13	13
4	dB	DBS G	34	34
5	K	DBS T	126	126
6	MHz	DBS Bandwidth	24	24
7	dBW	DBS Noise Figure kTB	-133.8	-133.8
8	dB	DBS Pointing Loss	-0.5	-0.5
15	dB	Atmospheric Absorption		-0.2
9	dBW	DBS Received Signal C	-122.9	-125.6
10	dB	DBS C/I Allowed	20	28.6
11	dBW	Allowable Interference	-142.9	-154.2
12				
13	dB	DBS Ant Gain toward horizon	0	0
14	dBW	Allowable RSSI	-142.9	-154.2

Table 2.2.2-2 DIRECTV calculation of allowable RSSi (corrected). The term in line 15 was added to account for the reduction in the BSS signal because of atmospheric absorption. These calculations do not include adjacent BSS satellite interference.

2.2.3 Consistency of Allowable RSSi to Proposed Long Term, Single Entry NGSO EPFD Limit

The maximum allowable RSSi as calculated can be shown to be very consistent with the proposed single entry epfd mask for the protection of 45 cm BSS receive antennas. This proposed mask is contained in Figure 8.1-1 of Technical Appendix A, and is reproduced below in Figure 2.2.3-1.

To provide a direct comparison between the proposed epfd mask to protect 45 cm BSS antennas and the calculated maximum RSSi, the RSSi value needs to be converted to an epfd. This conversion is shown in Table 2.2.3-1.

The adjustment from a pfd to an epfd requires the subtraction of the gain difference between the antenna gain at the point of interference reception and the peak antenna gain. In this case, the antenna gain at the point of interference reception is taken as 0 dBi, and the peak gain of the antenna is taken as 34 dBi.

Maximum Allowed RSSi in 24 MHz	-154.2	dBW/24 MHz
Bandwidth Conversion to 4 kHz	-37.8	dB
Correction for Isotropic Area	43.4	dB/m^2
Received pfd	-148.6	dBW/m^2/4 kHz
Adjust for gain difference to antenna peak gain	-34	
Received epfd	-182.6	dBW/m^2/4 kHz

Table 2.2.3-1: Conversion of RSSi to epfd

Interference from a Northpoint transmitter can then be represented on an epfd graph as a constant interference source (with the exception of unpredictable and variable multipath effects). As such, it appears on an epfd graph as a vertical line representing a long-term interference source. A vertical line has been added to Figure 2.2.3-1 representing the received epfd value of -182.6 dBw/m^2/4 kHz for a Northpoint transmitter. Note that the long-term component of the proposed NGSO interference mask is at a value of -183 dBw/m^2/4 kHz, which each NGSO system would have to meet for up to 99.34% of the time. Thus, these two long-term single entry epfd values -- one for protection from a Northpoint interference source and one for protection from a single NGSO system -- are nearly identical.

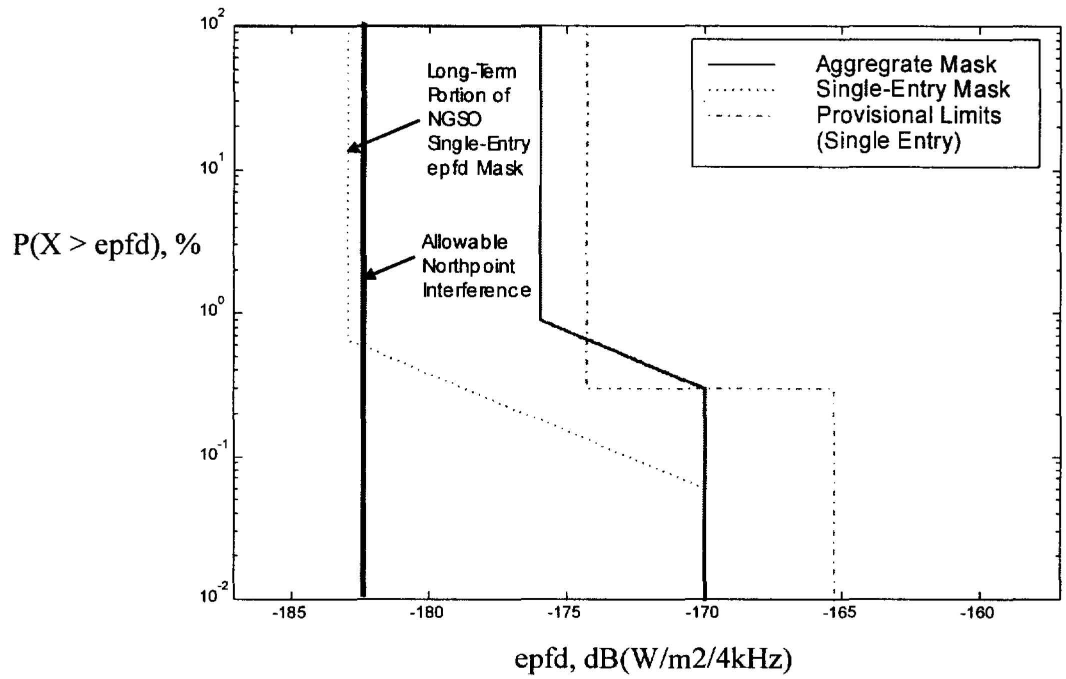

Figure 2.2.3-1: Comparison of Maximum RSSi and NGSO Limits

2.2.4 Analysis of High Interference Zones within Northpoint Coverage Area

Figure 2.2.4-1 shows Figure 2.1-2 with a horizontal line added to represent RSSi = -154.2 dBW as required from Table 2.2.2-2. Regions where the RSSi is greater than or equal to -154.2 dBW have unacceptable levels of interference. *It is clear that virtually the entire Northpoint operating zone from the transmitter out to about a 12-km range will produce unacceptable interference into the US-GSO 1(a) link.*

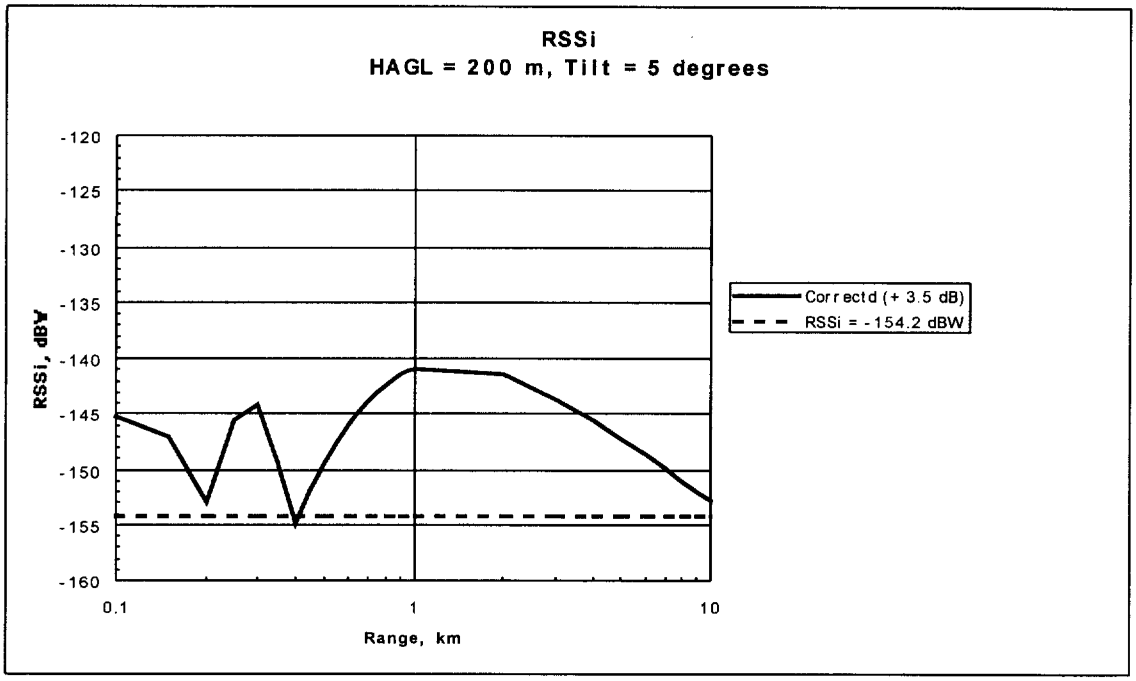

Figure 2.2.4-1 Graph of Northpoint generated RSSi versus maximum permissible RSSi (calculated using corrected BSS link parameters).

Figure 2.2.4-2 shows the minimum separation distance calculated using a maximum permissible RSSi of -154.2 dBW (corresponding to C/I = 28.6 dB) and with a RSSi of -159.5 dBW defining the Northpoint service area. The dashed line in Figure 2.2.4-2 represents the required separation distance between the Northpoint transmitter and the BSS receive antenna. Any BSS receivers closer to the Northpoint transmitter than this separation distance will receive *unacceptably high interference*. This is a very large area (more than 50% of the service area), and it is *absurd* to expect to be able to perform some form of mitigation (such as shielding) on all BSS receivers in this large area. In addition, receivers outside this area will receive high interference levels due to multipath effects, which are very unpredictable. This calculation uses a Northpoint tower height of 150 m, a tilt of zero degrees, and a horizon gain for the BSS antenna of 0 dBi. These calculations include the ($1/\text{range}^2$) falloff of transmit signal power, as well as estimates of the Northpoint transmit antenna gain pattern. The antenna gain pattern is based on information from the Northpoint Technical Annex and its associated Engineering Exhibit prepared by Delawder Communications. Terrain features are not included in this general analysis. To calculate the Northpoint service area DIRECTV used the link budget developed in the Northpoint Technical Annex and shown in Figure 2.1-1 above.

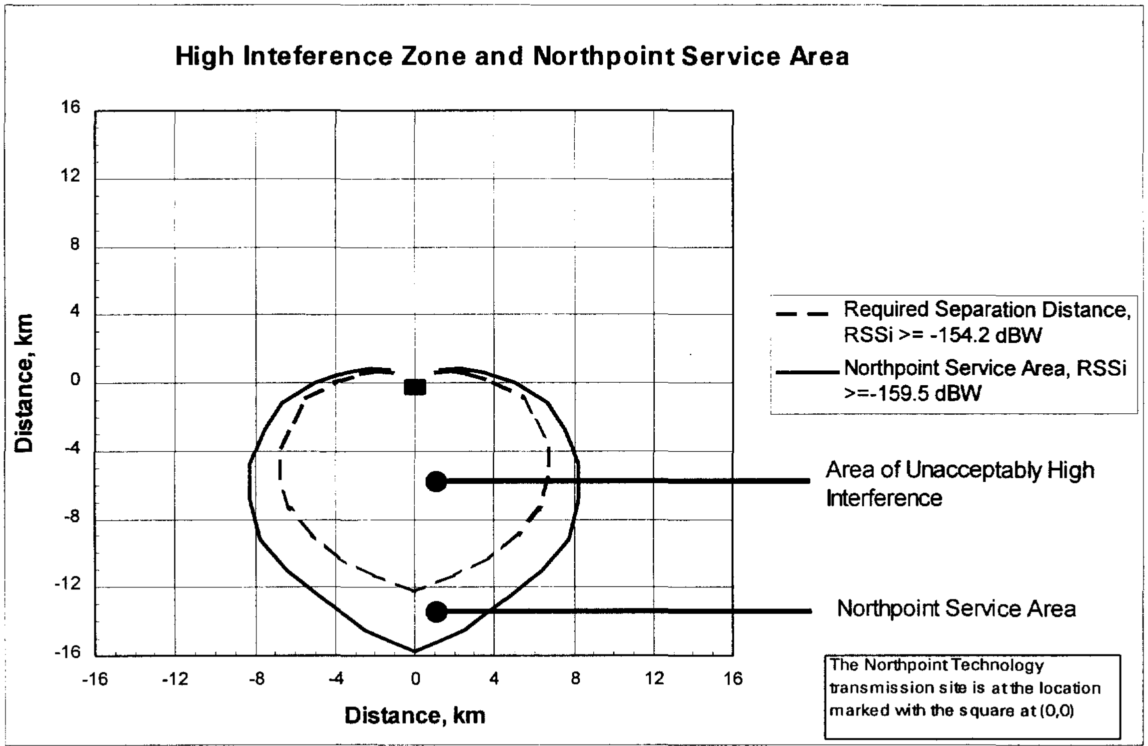

Figure 2.2.4-2 Estimate of required separation distance with BSS earth station (BSS antenna horizon gain is 0 dBi and Northpoint tower height is 150 m).

From these calculations it is possible to make general comments about the size of the high interference zone. The high interference zone is defined as the area enclosed by the dashed line, and it is a significant part of the overall Northpoint service area (which is defined by the solid line). The operating zone for Northpoint would feature RSSi values between -154.2 and -159.5 dBW, a difference of only 5.3 dB. As can be seen from Figure 2.2.4-2, the high interference zone extends well beyond those ranges where tilting the Northpoint transmitting antenna reduces the RSSi. Rather, it is in the regime where the fall-off of RSSi depends on distance from the transmitting site (the well-known 1/range^2 dependence for electromagnetic-wave propagation). This is highlighted in Figures 2.2.4-2 and 2.2.4-3 which show the Northpoint service areas (that is, areas where the Northpoint RSSi is -159.5 dB or higher) and the required separation distance to protect BSS (line where the Northpoint RSSi is -154.2 dBW). Figure 2.2.4-2 is similar to Figure 2.2.4-3 except that a Northpoint antenna height of 200 m and a beam tilt of 5 degrees are used in Figure 2.2.4-3 (as described in Northpoint's Technical Annex).

Note that under clear sky conditions and no fade margin, the Northpoint service area (which will be referred to as the "clear sky service area") extends out to about 24 km from the transmitting site. When the service area is calculated by including an additional -3.5 dB to account for rain fade and other effects (as described in the Northpoint Technical Annex) the maximum service distance shrinks to about 16 km. Under these conditions, the high interference zone is *more than 50% of the actual Northpoint service area.*

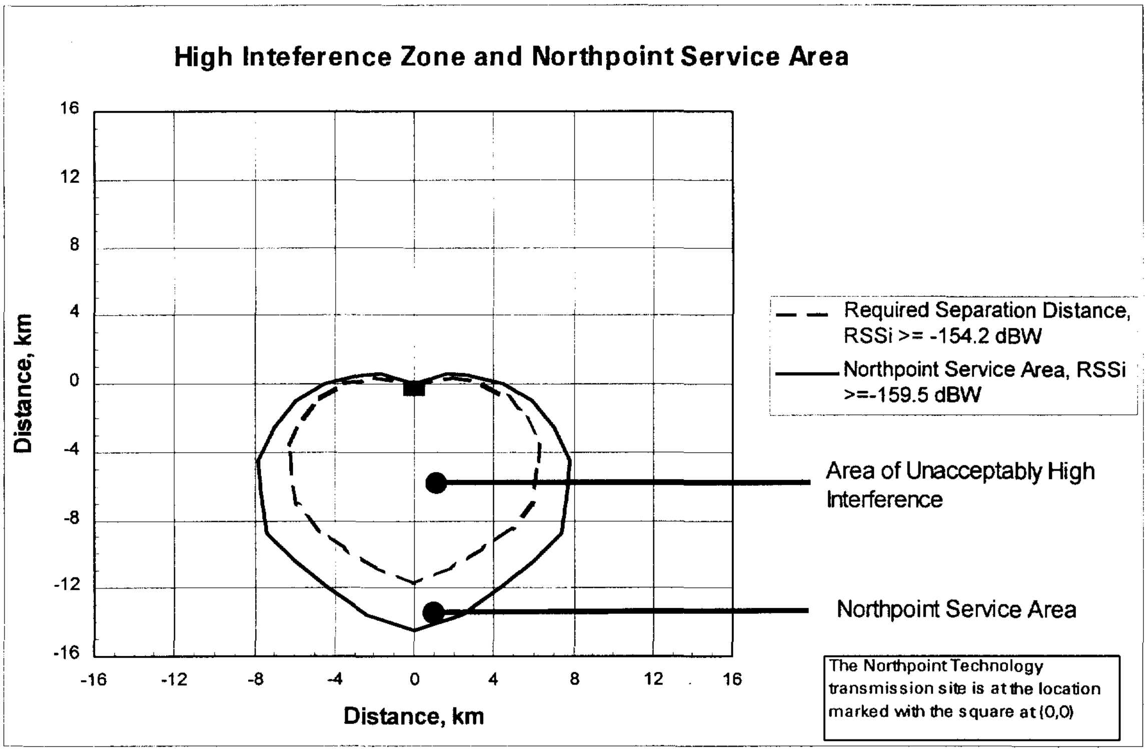

Figure 2.2.4-3 Estimate of required separation distance with BSS earth station (BSS antenna horizon gain is 0 dBi, Northpoint tower height is 200 m, and Northpoint antenna tilt is 5 degrees). The high interference zone is the area enclosed by the dashed line and is a significant part of the overall Northpoint service area.

Another issue regarding separation distances needed to protect BSS systems can be observed in these figures. It is apparent that significant overlap between Northpoint operating zones will be required. If a BSS receiving system is located near the boundary of two or more Northpoint service areas, the BSS system will encounter interference from *each* Northpoint system. This means that the aggregate interference for these BSS receivers will consist of contributions from multiple Northpoint signals originating from different directions, and the aggregate interference may be significantly higher than would be expected from only one Northpoint system alone. Furthermore, as stated in Northpoint's testimony before the House Commerce Subcommittee on Telecommunications, Trade and Consumer Protection on February 24, 1999, "[i]n the Northpoint system, most customers will have at least 3 directions to point their dish to pick up our service."[6] Hence, contributions from multiple interference sources will result in an

[6] Statement of Sophia Collier, President and CEO, Northpoint Technology, Inc., before the House Commerce Subcommittee on Telecommunications, Trade and Consumer Protection (Feb. 24, 1999).

appreciably higher aggregate interference on BSS receiving systems -- by Northpoint's own admission, perhaps *three times* (4.77 dB) as much.

Similar calculations can be performed for Northpoint transmitter siting scenarios which would be much more reasonable than those using very tall towers. Figure 2.2.4-4 displays the required separation distance and Northpoint service area calculated using a transmitter tower height of 50 m and a Northpoint antenna tilt of 5 degrees. The high interference zone and the Northpoint service area are very similar to those shown in Figure 2.2.4-3.

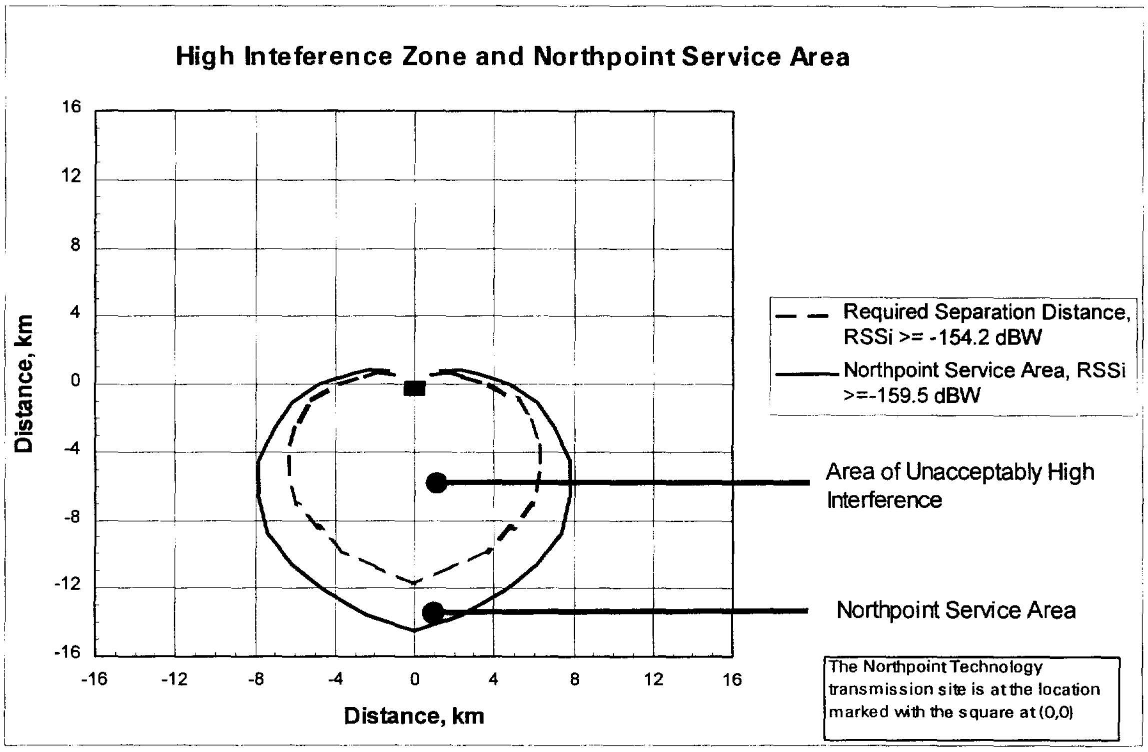

Figure 2.2.4-4 Estimate of required separation distance with BSS earth station (BSS antenna horizon gain is 0 dBi, Northpoint tower height is 50 m, and Northpoint antenna tilt is 5 degrees).

2.2.5 Impact of Northpoint Proposed Transmitter Power Increase

In a recent letter to the FCC, Northpoint proposes that "if a system was constructed in an area removed from existing DBS subscribers, it would have more leeway to use considerably higher EIRP."[7] The "Maximum Transmit EIRP" then noted in the transmit

[7] Letter to Magalie Roman Salas, Secretary, FCC, from Broadwave Denver L.L.C. (Jan. 8, 1999).

information block is given as 45 dBm. This transmit power is 32.5 dB higher in power (a factor of 1,778) than the proposed nominal operating EIRP of 12.5 dBm.

First, the impact of such a transmitter power increase on the separation distance is dramatic. Transmission spreading loss is proportional to the square of the increase in distance. A required typical separation distance of 12 km, as derived in the above calculations, must be increased to $(12km) * (1778)^{0.5}$ or 506 kilometers. This is beyond the horizon. Thus, any BSS receive antenna within sight of a transmitter of this power will receive critical levels of interference. Most receivers, in fact, will probably fail to operate.

Furthermore, DIRECTV receivers are being installed in all regions of the country *without restriction.* Installation of such a transmitter would preclude the use of BSS receivers anywhere in the area until such a transmitter was turned off. This is clearly unacceptable given the philosophy underlying the DBS service, which is the unhindered installation of DBS receivers anywhere in the country, especially in providing service to rural and remote areas.

2.3 Summary of Northpoint - BSS Sharing Analysis

- An equitable inter-service sharing criterion was developed which allocated 2% of BSS unavailability degradation to the Northpoint service. This is the same sharing criterion that other inter-service systems --, *i.e.*, NGSO FSS -- have generally agreed to meet.
- Using this sharing criterion, the separation distance required between the Northpoint Transmitter and any DBS receive antenna is very large, and the high interference area so enclosed represents a huge fraction of the proposed service area.
- The required separation distance is largely independent of any of the proposed transmitter mitigation techniques.
- Multipath effects, seen in the Austin experiments to be as high as 13.3 dB above nominal signal level, will only serve to increase this high interference area.
- Mitigation techniques over such a large high interference zone, such as the proposed shielding of DBS receive antennas, would be prohibitively costly and are directly counter to the DBS philosophy of easy-to-install antennas.

Therefore, the proposed Northpoint system, when required to meet the same equitable sharing criteria as other non-DBS services within the band (as it should be) is clearly untenable at 12 GHz.

3 COMMENTS ON NORTHPOINT FIELD TRIALS

While section 2.0 demonstrated the technical reasons why the Northpoint system is not a viable service that can co-exist with DBS operations at 12 GHz without causing harmful interference, this section summarizes several critical deficiencies in Northpoint experimental field data and test methodologies. It also points out that even within the data accepted at face value, there is clear evidence of widespread and harmful interference to DBS receive antennas.

DIRECTV has reviewed the progress report of Diversified Communication Engineering, Inc. (WA2XMY) submitted on behalf of Northpoint regarding experiments conducted in Austin, Texas, dated December 1998 ("Northpoint Testing Report") -- a purported demonstration of Northpoint/DBS compatibility in an urban environment. Northpoint makes numerous assertions in the progress report that are clearly erroneous and demonstrate a complete lack of understanding of the complex technical issues involved with potential harmful interference effects of the Northpoint system on the provision and receipt of high-quality BSS service.

In addition, using data obtained by DIRECTV during portions of the Austin experiment and using data from Northpoint's own report, DIRECTV shows that the DIRECTV service's link unavailability was seriously degraded at most Northpoint test sites -- degraded far beyond the 2% degradation criterion discussed in Section 2.

3.1. Difficulties with Northpoint Data Collection Methodology

In its Austin experiment, Northpoint utilized multiple uncontrolled variables, unrepeatable data collection techniques, and incorrect transmission bandwidths. These deficiencies are described below. And, while the deficiencies attending the particulars of the tests described below are self evident, several critical flaws in Northpoint's testing should also be noted:

1. No attempt was made to collect data in manner applicable to markets across the U.S., although results are asserted to be applicable;

2. Northpoint's test methodology was not established to rigorously test its assertions as the scientific method would dictate, but instead appears to be crafted primarily to justify Northpoint's arguments; and

3. Northpoint's data collection techniques were so poor as to make reproduction of the results by an independent party at a later date extremely difficult.

3.1.1 Northpoint Test Program Utilized Multiple Uncontrolled Variables and Unrepeatable Data Collection Techniques

Northpoint's experimental reports make no mention or measurement of the DBS antenna sidelobe patterns or the variability of these patterns between antenna manufacturers, both of which are real-world problems that are found in DBS subscriber installations, and that have been documented in JTG 4-9-11/356. To illustrate, it is not known how many of the Northpoint test sites fell within nulls of the particular antenna chosen for the test, thereby providing unrealistically optimistic results for Northpoint. However, that will be impossible to determine since accurate measurements of the test DBS antenna sidelobe pattern are not provided in Northpoint's report, nor is the actual performance of the particular DBS LNB known. DIRECTV knows, from its own extensive testing, that variation in a single parameter such as noise figure can be as much as 0.5 dB. This has a significant effect on link performance.

3.1.2 Northpoint's 8 MHz Bandwidth Test Signal is Misleading

Northpoint's test signal should have occupied a 24 MHz bandwidth to more accurately represent the proposed interference environment. Instead, the Northpoint test signal occupied only 8 MHz of bandwidth. No experiment was performed to clearly show how test results derived from the use of a narrower test signal might be adjusted to compensate for this difference. The use of an 8 MHz occupied bandwidth hardly provides a robust demonstration of Northpoint claims, nor provides a fair representation of the Northpoint system's proposed implementation. This and other serious test deficiencies cast doubt on the Northpoint claims of non-interfering performance.

3.1.3 Northpoint Test Methodologies Yield Questionable Data

The most important piece of data acquired in the Austin experiment was the collection of DBS satellite signal meter values. The satellite signal meter, which is included in every DIRECTV satellite receiver, was originally designed as an indicator of received signal strength for aligning a subscriber's antenna. In technical terms, the meter reading is proportional to received carrier-to-noise ratio. The meter reading will increase as the received satellite signal increases in strength, and will decrease when the satellite signal is reduced. Since the meter is also sensitive to received noise levels, the signal meter will decrease if the received noise level is increased. This increased noise can come from any source seen by the antenna, including a Northpoint transmitter. Such reductions in signal meter readings were clearly seen at all Austin test sites.

Although the signal meter included in each DBS satellite receiver is not a highly calibrated device, it is very useful in indicating relative changes in received carrier-to-noise ratio. Proprietary data is not necessary to convert signal meter readings to received carrier-to-noise ratio. A simple test, which can be performed by anyone, is to slowly reduce the C/N ratio at the input to a receiver while alternately observing received carrier power and true received noise on a spectrum analyzer. Carrier power variations are easily obtained by off-pointing a DBS receive antenna away from peak received signal. True noise is easily obtained by pointing the DBS receive antenna well away from the satellite being used. The calculated C/N ratio can then be plotted against recorded signal meter readings.

In the portion of the Northpoint testing that DIRECTV witnessed, field signal meter data were collected by one person reading the signal level meter, performing a mental average of a number of samples and vocalizing the result to someone else who recorded the data by hand. This is clearly an error-prone technique at best. DIRECTV offered to provide an automated test setup for Northpoint at DIRECTV's expense for the purpose of automatically recording such data, but Northpoint was unwilling to wait for this hardware to be shipped. It would have added much more credibility to the data gathering process.

3.1.4 Selective Recording of Data

A clear indication of the problems inherent in this kind of subjective data collection is the statement in Northpoint's report that "there was no user-detectable DBS interference at any site of the survey." Northpoint Testing Report at 9. To the contrary, while

DIRECTV personnel were present and observing, the Northpoint transmissions not only interfered with the DBS signal, but actually *caused total loss of picture on several occasions*. Clearly there is a difference of opinion between DIRECTV, which has invested hundreds of millions of dollars to provide the highest availability signal in the industry, and Northpoint, which relies on repeated, unsupported assertions, regarding the definition of acceptable interference. At best, based on DIRECTV's direct observation, the Northpoint approach to data collecting can be fairly described as non-scientific and random in nature.

3.1.5 Lack of Understanding of True Impact of Interference on DBS Link

Northpoint's lack of understanding of BSS digital transmission is further evidenced by its discussion of the signal meter (which Northpoint refers to as the "DBS Signal Strength Pointer (ssp)"). In this section of the report, Northpoint describes how, in a laboratory environment, Northpoint injected noise into a DBS system and was able to vary the signal strength meter from 0 to 90, concluding that "It was observed that a related TV picture continued to remain OK until the ssp value was reduced to 10 or less on the 0-100 scale. This suggests that for the ssp scale, the error rate is tolerated by the system for ssp values over most of the displayed range of 0-100." Northpoint Testing Report at 17. Northpoint's first point simply describes the advantage of a digital system where, unlike an analog transmission that develops "snow" and other artifacts as the interference level is increased, the digital picture remains nearly pristine until it is overwhelmed completely by the interference. To then infer in the next sentence, as Northpoint does, that it is acceptable to drive the DBS signals down to a signal level of 10, displays the lack of understanding of the role of clear sky margin in a DBS link. High clear sky margin is *absolutely critical* in dealing with real-world conditions such as rain attenuation, antenna pointing errors, installation problems, adjacent satellite interference, and other effects. The DBS signal has been designed with a high clear sky margin to deal with these effects and still provide a high quality of service. DIRECTV and other DBS providers have literally spent years of technical study and design and millions of dollars to achieve the high level of signal robustness demanded by today's consumers. Signal quality is becoming ever more important as cable companies upgrade their systems. Any reduction in clear sky margin directly impacts service quality by increasing sensitivity to rain fades. This is why ITU-R JWP 10-11S, in their October 1998 PDNR, limited the degradation in BSS signal unavailability to 10% or less from all NGSO FSS sources. It is a critical parameter, and must be protected.

3.1.6 Interpretation of Multipath Data

Without belaboring the point, a final example of Northpoint's poor methodology and lack of understanding of BSS signal transmission can be found in its discussion of multipath and signal reflections. Northpoint seems surprised by the result at Site 20, where the Northpoint receive antenna had line-of-sight ("LOS") blockage from a building: "the Northpoint signal was acquired from building reflections," yet no interference was observed at all by the DBS receiver. It is entirely possible, in fact likely, that the Northpoint antenna was at a peak in the reflections while a DBS antenna a few feet away was in a null. Such is the complex nature of reflections at these shorter wavelengths. In a later paragraph, Northpoint presents data that show the reflected signal more than 13.3 dB higher than the direct signal. How is the consumer marketplace to deal with the vagaries of such a situation? Any competent RF engineer knows that an acceptable location one moment can be unacceptable the next due to atmospheric changes or even a large truck driving by. Not only the data, but the basic concept of even trying to draw meaningful conclusions from this environment is specious where the best that could ever be said is that some anecdotal results were obtained for a specific time, location, and set of Northpoint's testing conditions.

3.1.7 Summary of Northpoint Experimental Testing Methodology

DIRECTV made a good faith effort to support Northpoint's testing in order to acquire meaningful technical results. As Northpoint correctly states in its report, DIRECTV and others did provide input to the Northpoint test plan. However, the report incorrectly implies that some sort of concurrence with the validity of the testing was given. This is patently false. In fact, as DIRECTV has suspected, Northpoint now seeks to extrapolate these questionable results from a single site to nationwide licensing. The single site concept is clearly unsupportable since the supposed technical basis for Northpoint's system is the separation between signals, yet Northpoint chose a test site where the elevation angle of the DBS antenna (and hence separation) is at its greatest point anywhere in the continental United States and a site where rainfall is not generally a problem. A test site in Seattle would potentially have yielded far different results.

There are serious deficiencies in Northpoint's test methodology, selection of favorable data for reporting, and serious mis-interpretation of data results. The following section analyzes Austin test data, both that obtained by DIRECTV through its own observation and that published by Northpoint, for its impact on BSS link unavailability. Even given the deficiencies noted above, it can clearly be seen in the data that DBS service quality was badly affected.

3.2 Degradation in DBS Link Unavailability in the Austin Tests

The following section will demonstrate the following points;

- A reduction in signal meter reading of less than 1 signal meter unit (0.6 units) is sufficient to obtain a 2% degradation in unavailability (for the conditions present in Austin, Texas in December of 1998).
- Northpoint published data indicates that at 28 of the 29 test sites, signal meter reading reductions were larger than 0.6 units when Northpoint transmitter interference was present, indicating unacceptable levels of interference and consequential reduction in service quality. These results generally confirm the analysis in Section 2, which indicates that unacceptable interference will be seen over a majority of the Northpoint service area.
- At one location (site 3), the signal meter reading reduction was observed by DIRECTV to be about 30. This indicated a reduction in received C/N ratio from 12.1

to 7.7 dB, which is highly damaging. The corresponding degradation in unavailability is 338%, from an average of 16.5 hours of rain outage per year to an average of 72.1 hours of rain outage per year. This is far in excess of anything that could be considered as acceptable.

3.2.1 Signal Meter Equivalent to a 2% Reduction in Unavailability

An estimate can be made of the DIRECTV link budget performance for Transponder 18 in the Austin, Texas area for December of 1998. The satellite EIRP can be estimated at 51.4 dBW, with a received Carrier to Noise (C/N) ratio of about 11.5 dB for a well-pointed antenna. Using the same methods described in Section 2.2, one calculates a required maximum C/I ratio for Northpoint interference of 28.2 dB (unfaded carrier). This will degrade service unavailability in Austin by 2%, from 17.96 hours per year to 18.31 hours per year (on average). Adding this amount of interference (C/I = 28.2 dB) to the existing C/N ratio of 11.5 dB gives an overall reduction in C/N to 11.4 dB.

Table 3.2.1-1 provides some typical characteristics of a DIRECTV satellite receiver signal meter. The absolute value of C/N ratio is not well calibrated for these signal meters, but the relative change in C/N with signal meter units is reasonably accurate. The slope of the signal meter curve in the vicinity of 11 dB is approximately 6 signal meter counts per a C/N change of 1 dB. Therefore, a change of 0.1 dB in C/N ratio, which corresponds to a 2% change in unavailability at Austin, is 0.6 signal meter units -- less than one signal meter unit.

C/N Ratio, dB	Typical Signal Meter Reading (arbitrary units)
16.0	95.00
15.0	94.00
14.0	91.00
13.0	89.00
11.9	83.00
10.2	74.00
9.0	65.00
7.6	53.00
6.2	42.00

Table 3.2.1-1: Typical Signal Meter Readings vs C/N Ratio

3.2.2 Observations of Signal Meter Reductions in the Austin Experiment

Signal meter observations were made at all sites as a part of the Austin experimental test. These readings, of both transponders with and without interference, are summarized in

Figures IV-5 and IV-6; "Table - Signal Powers and Signal Strength Pointer Index," of the Northpoint progress report of December, 1998. Averaged signal meter readings and signal reading changes with interference are recorded in the columns of this figure, and are labeled "sspo" and "dssp" respectively. The column "ssp" records the averaged signal meter readings of transponders 16 and 20, which were apparently clear of Northpoint interference. The column "dssp" is the difference in averaged signal meter reading between those for transponder 18 and the combined average values for transponders 16 and 20. Transponder 18 contained the Northpoint interference, and thus "dssp" is an estimate of the reduction in signal meter units of transponder 18 when subject to interference.

A more accurate method would have been to only record values for transponder 18, both with and without interference. (This was not possible since the Northpoint transmitter was not continuously manned while in operation.) This would have eliminated any transponder-to-transponder differences between transponders 16, 18 and 20.

However, when taking the data at face value, one sees that *only one of the 29 sites* has recorded an acceptable average signal meter reduction ("dssp" column) of less than 0.6 counts. Table 3.2.2-1 provides a reproduction of the relevant sections of Figures IV-5 and -6 of the December 1998 progress report. The list has been sorted, from highest to lowest value of dssp. Virtually all sites failed the important interference criterion.

Site No.	Name	sspo	dssp
3	Palmer	75.5	12.9
1	Hyatt	78.8	11.6
7	Palmer*1	80.3	7.1
4	American-Statesman	83.2	6.2
9	Palmer*3	66.8	6.2
12	3rd & Christopher	69.8	4.2
13	Barton Creek Mall	83.4	3.2
8	Palmer*2	78.2	2.9
22	4th St. & San Antonio	78.2	2.8
15	IH-35 South	84.8	2.6
25	7th St. & Baylor	81.7	2.6
26	Southwest Pky 1	81.4	2.3
6	Coliseum	80.7	2.3
10	TX-DOT	80.6	2.3
24	11th St. & Guadalupe	80.2	2.3
11	3rd St. & Jewell	87.8	2.2
5	Jalisco's	86.0	2.2
28	Gains Ranch Rd	80.8	2.2
2	Salvation Army	86.1	2.0
27	Southwest Pky 2	83.1	2.0
16	Dais Ln Hill	88.5	1.9
13A	Barton Creek Mall	86.1	1.8
19	Glass Rd	82.4	1.8
14	Acc Pinnacle	85.4	1.7
21	Summit	85.9	1.4
29	HEB 1st & WnCannon	80.6	1.4
20	Fiesta Shores	81.2	1.3
18	Guerrero	80.1	1.2
13A-2	Barton Creek Mall	86.3	0.9
23	7th St. & Guadalupe	86.0	0.7
17	Thaxton	85.8	0.1
9A	Palmer*3	N/A	N/A

Table 3.2.2-1: Northpoint-Reported Signal Meter Reduction Values

In the December progress report, Northpoint characterizes these changes in signal meter reading as "slight depression(s)" (Page 21, December 1998 Progress Report). However, in light of their real impact on DBS signal unavailability, and in comparison with protection criteria established for similar services, these signal meter reductions are anything but "slight depression(s)" -- they in fact are quite significant.

3.2.3 Calculated Degradation in Service Unavailability at the Palmer Site

Table 3.2.3-1 presents the calculated increase in unavailability for 3 sets of test data taken at the Palmer site of the Austin experiment. Cases A and B represent data taken with DIRECTV present but not reported by Northpoint due to an alleged calibration problem. However, DIRECTV could not support such a finding and believes the data to be worthy of consideration. Case A data was taken on December 8, and Case B data was taken on

December 9. The signal meter readings indicated are averaged data taken only on Transponder 18. The interfering transmitter was turned on and off for these tests, and was reported to be transmitting at the nominal level when turned on. The satellite receiver signal meter does not need to be calibrated since in this case we are examining the relative difference between signal meter readings taken on the same transponder.

Case	**A**	**A**	**B**	**B**	**C**	**C**
Interference Present	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**
Signal Meter Reading	85.8	68.7	84	53.9	75.5	62.6
Estimated C/N+I	12.4	9.5	12.1	7.7	10.5	8.7
Estimated C/I Ratio due to Interference		12.6		9.7		13.4
Average Annual Unavailability Hours	14.7	30	16.5	70.8	34.1	59.5
Percent Increase in Unavailability		104%		329%		74%

Table 3.2.3-1: Calculated Increase in Unavailability, Palmer Site

As shown in the Table, the signal meter reading for transponder 18 decreased by an average of 17.1 units for Case A, and 30.1 units for Case B. These large signal meter decreases indicate that the interfering C/I ratio was approximately 10 to 12 dB. This is far from the required 28.2 dB derived in Section 2. *The calculated degradation in service unavailability ranged from 100% to well over 300%, with the average number of signal outage hours per year increasing dramatically from 16 to 71 hours.*

Case C represents data taken by Northpoint and reproduced in Figure 3.2.2-1 above. DIRECTV was not present when this data was taken. The meter reading for the case without interference is low, indicating either a strong weather influence or a poorly-pointed receive antenna. The data were analyzed as presented, and show results very similar to Cases A and B. The interfering C/I ratio is estimated to be 13.4 dB, and the degradation in service unavailability was calculated at 74%, with the outage hours per year increasing from 34.1 to 59.5 hours.

3.2.4 Summary of Austin Test Data

It has been demonstrated that in order to meet the required sharing criterion, C/I ratios greater than 28 dB are required. For the Austin site, the corresponding reduction in field satellite receiver signal meter units can only be at most 0.6 units. All sites but one in the Austin experiment failed to meet this criterion. In addition, one site was calculated to have annual outage hour increases of 100% or more due to the addition of Northpoint interference. In the 12 GHz band, the Northpoint proposal and design is clearly incompatible with the provision of quality DBS service.

Finally, it should be noted that the interference effects evidenced by the Northpoint data are long-term and cumulative. Because of the DIRECTV service's substantial "clear weather" signal margins, Northpoint signals may not always cause visible disruption to DIRECTV's digital signals. However, if the Northpoint system is actually deployed, the interference that it will create in the 12 GHz band over time will lower these clear weather margins and cause a significantly increased number of downlink rain outages which, for example, will last for increasingly longer periods of time. These effects might not manifest themselves in a month-long test, but the interference created by the Northpoint system has been evidenced nonetheless. Regardless of whether Northpoint interference completely eliminates a subscriber's picture, its consequences are no less severe for DBS subscribers, who have come to expect picture quality, service availability and reliability that is superior to that provided by other MVPDs, including incumbent cable television operators.

C

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